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(71) Applicant *(for all designated States except US)*: KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: DOOLEY, Saul, R. [GB/GB]; c/o Philips Intellectual Property & Standards, Cross Oak Lane, Redhill, Surrey RH1 5HA (GB).

(74) Agent: SHARROCK, Daniel, J.; Philips Intellectual Property & Standards, Cross Oak Lane, Redhill, Surrey RH1 5HA (GB).

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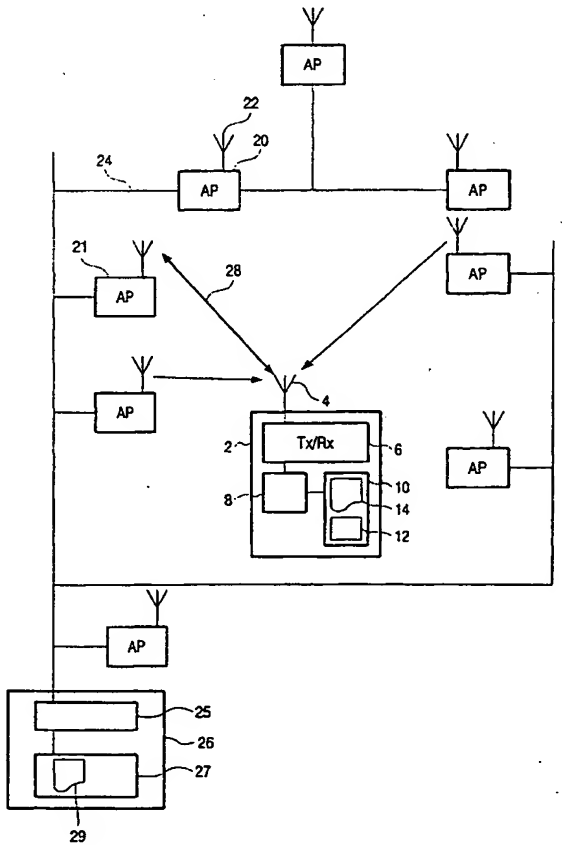
(54) Title: POSITIONING METHOD, SYSTEM AND UNIT



(57) Abstract: A mobile unit (2) receives signals from a plurality of base stations (20) and creates a list (14) of base stations (20) from which signals are received. A location query is then transmitted through a communications link (28) and network (24) to a location server (26), the location query including the list of base stations. The location server (26) then calculates the location.

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Declaration under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DESCRIPTION

POSITIONING METHOD, SYSTEM AND UNIT

The invention relates to a positioning system and method and unit therefor.

"Cell-ID" is the generic term for a simple form of positioning where one device in communication with another device of known location uses the known location as its location. This concept is powerful in short wave wireless communications since the devices in communication with each other are by definition only a short distance apart and hence the location used is not in error by very much. Unlike more common positioning systems such as the Global Positioning System (GPS) these positioning systems are simple to implement and low cost.

Examples include cellular positioning Cell-ID and Bluetooth Local Positioning.

Using Bluetooth, a fixed network of access points (APs) are provided. The user has a mobile unit with a Bluetooth, radio frequency (RF) connection to one of the access points. One of the APs is a Location Server, which maintains a list of the AP identifiers and their locations, and is responsible for responding to location requests from the user. If the user requests his location, the Location Server responds with the location of the AP to which the user is connected. Bluetooth Local Positioning is accordingly very useful in indoor environments where GPS performance is poor, and especially in environments having a dense network of APs.

Optionally, Bluetooth Local Positioning may use a measure of received signal strength to improve positioning accuracy slightly, though such signal strength measurements are not usually very accurate in indoor environments.

In the future, higher power Bluetooth beacons and more sensitive mobile units are expected, which should increase the range of the beacons, and hence the size of the Bluetooth cell to about 100m or perhaps even more.

However, this will mean that the accuracy of Cell-ID type positioning systems will only be of order 100m, which is far too coarse for most location-based applications. A more accurate estimate of location enables far more options.

Accordingly, there remains a need for more accurate positioning using networks such as Bluetooth, as well as conventional cellular networks.

According to the invention there is provided a positioning method for a mobile unit used in a network having a plurality of fixed base stations linked to a location server, comprising:

receiving in a mobile unit signals from a number of the fixed base stations and creating a list of the base stations;

transmitting to one of the base stations through a communications link a location query including the list of base stations from which signals are received;

passing the location query through the network to the location server; and

determining the position of the mobile unit from the information transmitted in the location query, including the list of base stations.

The inventors have realised that in Bluetooth and similar systems such as cellular telephony systems involving a network of short range base stations, called APs for Bluetooth, the user regularly monitors at least two APs for example for reasons of handover, i.e. to allow the user to move from the coverage area of one AP to another. Thus, the user in any event maintains a list of APs that the user can detect. According to the invention, this list is collected by the mobile unit and sent through the network to a location server which can thereby much more accurately estimate the user position than by using existing approaches. Moreover, the method has a very low overhead.

The system is much more convenient and practical than a system in which multiple networked APs determine whether they are in communications range of the mobile unit. The mobile unit itself can collate the list and initiate any queries needed to determine which base stations are in range. Further, since the list is collated in the mobile unit there is no need for the individual

APs to communicate with each other in the network to collect the information about which APs are in communication with the mobile unit, which reduces network overhead.

Conveniently, the method includes:

sending an inquiry message from the mobile unit;

receiving the inquiry message in one or more base stations and transmitting inquiry responses back from those base stations to the mobile unit, the inquiry responses including the address of the responding base station; and

listing the received addresses in the mobile station for onwards transmission in the location query.

By "inquiry" is meant the process of discovering or detecting an AP or base station in the vicinity, and no restriction to Bluetooth or similar networks is intended by this term.

In embodiments, a communications link will be formed with a single one of the base stations. Under predetermined conditions, the communications link between the mobile unit and the single one of the base stations may be handed over to another of the base stations in the handover list to form a communications link between the mobile unit and the other one of the base stations. This may be necessary or desirable in the event that the mobile unit moves too far from the initial base station, or transmission between the mobile unit and the initial base station becomes impeded, or simply because the initial base station becomes overloaded and other resources are available elsewhere.

In this case, the method may include sending in the location query as the list of base stations a copy of the handover list. The point is that the handover list is maintained in any event in the mobile unit for the purposes of handover so the method according to the invention adds very little overhead.

For improved accuracy, the method may further include measuring the signal strength of the signals received in the mobile unit from the fixed base stations; and including the signal strength information in the location query passed to one of the base stations. The step of determining the position may

then use the signal strength information together with the list of base stations to determine the position of the mobile unit.

In a preferred embodiment the base stations are Bluetooth access points and the mobile unit is a Bluetooth device.

In another embodiment the base stations are cellular base stations and the mobile unit is a cellular mobile unit such as a cellular telephone or a cellular telephone equipped PDA (personal digital assistant)

In another aspect, the invention relates to a mobile unit for use with a network of base stations having a location server; the mobile unit comprising:

a transceiver for transmitting messages to and receiving messages from the base stations;

wherein the mobile unit is arranged:

to receive signals from a number of the base stations; and

to transmit to one of the base stations a location query including a list of the base stations from which signals are received, so that the receiving base station can pass the location query through the network to the location server to determine the position of the mobile unit from the information transmitted in the location query, including the list of base stations.

In another aspect, the invention relates to a system with a plurality of base stations arranged in a network, each having a transceiver for connecting to a mobile unit; and a location server connected to the network including a list of base stations and their locations; wherein the network is arranged to receive a location query including a list of base stations in range of the mobile unit from the mobile unit and to pass the location query to the location server; and the location server is arranged to receive the location query and to determine the location of the mobile unit sending the location query using the list of base stations in range of the mobile unit and the list of base stations and their locations.

Embodiments of the invention will now be described, purely by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic drawing of a system according to a first embodiment of the invention;

Figure 2 is a schematic drawing of the messages exchanged when using the first embodiments;

Figure 3 is a schematic flow diagram of the operation of the embodiment of Figure 1; and

Figure 4 shows a Location Query Message.

A mobile unit 2 includes an aerial 4, a transceiver 6, processor 8 and memory 10. In the embodiment, the mobile unit 2 is a bluetooth device and the transceiver 6 is a bluetooth transceiver.

A number of bluetooth access points 20, i.e. fixed base stations, each having an antenna 22, are connected together by a network 24. The network includes a location server 26 which in the embodiment is separate from the access points 20, but could alternatively be included within one of the access points 20. The location server 26 includes a processor 25 and a memory 27 which includes an access point list 29 of the access points and their physical locations. By "memory" is meant any suitable data storage means, including ROM, RAM, disc storage, flash memory, tape, or any other type of electronic data storage.

Code 12 is provided in the memory 10 of the mobile unit 2 for carrying out bluetooth standard operations. The access points 20 and location server 26 include standard components such as networking cards, and code for using the network 24. Since these are well known to those skilled in the art, they will not be described further.

In use, when the mobile unit 2 is switched on an inquiry 50 is sent out (step 30) from the mobile unit in accordance with the bluetooth standard as illustrated in Figures 2 and 3. Any access points 20 in range respond (step 32) with inquiry responses 52 listing the address identifier of the responding bluetooth access point. The mobile unit then forms (step 34) an in-range list 14 of the received addresses and stores it in memory 10 in the mobile unit. The mobile unit then makes a connection (step 36) to one of the access points

20 in the list in accordance with the bluetooth standard, forming a communications link 28 with this access point that will be referred to below as the communicating access point 21.

When the mobile unit needs to determine its location it sends (step 38) a location query 54 through the communications link 28, the access point 20 and network 24 to the location server 26. The location query 54 (see Figure 4) includes a header 60, footer 62, and the addresses 64 taken from the in-range list 35 stored in memory 10 in step 34. As will be seen, the location query in this embodiment also includes the signal strengths 66 of the signals received from the access points, although this will not always be essential.

The location server 26 can use a number of approaches for turning the list of access points 20 into a fix of the position of the mobile unit. The simplest way of determining the position of the mobile unit is to average the locations of the access points included in the location query. The (x, y) coordinates of each access point in the list are simply averaged to determine the location of the mobile unit. The locations are determined from the access point list 29 in the location server.

Alternatively, the positions of the access points 20 may be combined using various weightings.

In the preferred variation of the embodiment of Figure 1 the location query message includes not merely the access points within range but also the signal strength of signals received from those access points, as shown in Figure 4. The locations of the access points are weighted with signal strength so that signals with lower strength are given less weight. Other measures of proximity or confidence may be used alternatively or additionally.

When the location server 26 has determined the location of the mobile unit 2 it then transmits a location estimate message 66 back through the network 24, the communicating access point 21 and communications link 28 to the mobile unit 2.

The initial inquiry sent in step 30 is the initial inquiry that is transmitted when setting up any bluetooth communications link to the mobile unit. It is also useful to determine the location long after this initial link has been set up.

Accordingly, the mobile unit in accordance with the Bluetooth standard maintains an in-range list 14 in memory 10 of access points in range. The in-range list may also be referred to as a handover list, since in this embodiment the reason for the mobile unit maintaining this list is to allow handover. When the mobile unit 2 moves out of range of the communicating access point 21, the mobile unit 2 has a list of the addresses of alternative access points 20 with which communications links 28 can be made, and makes a link 28 with one of these access points 20. Such handover need not solely be triggered by moving out of range of an access point, but any of a number of other scenarios are possible. For example, handover may take place when another access point has a stronger signal than the access point of the present communications link. Alternatively, an access point may become overloaded in which case the mobile unit 2 may form a communications link with an alternative access point.

In this approach, the location query sent in step 38 includes the handover list 14 as the list of access points 20 that are in range. By using the handover list, the location query can be implemented with very little overhead, since the handover list is in any event maintained.

From reading the present disclosure, other variations and modifications will be apparent to persons skilled in the art. Such variations and modifications may involve equivalent and other features which are already known in the design, manufacture and use of telecommunications systems and which may be used in addition to or instead of features described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of disclosure also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to any such features and/or combinations of such features during the prosecution of the present application or of any further applications derived therefrom.

Although the embodiment described relates to Bluetooth, the invention is not restricted to Bluetooth and may, for example, be applied in a cellular telephone system. In this alternative embodiment, the user sends a location request to the base station serving the mobile unit, together with the identifiers and/or addresses and signal quality measures of any other base stations the mobile unit can detect. The location server combines these positions and signal strength information to estimate the user's location.

The skilled person will be aware of many other communications standards that may be used. These include for example DECT or cellular standards such as GSM or UMTS. A mobile unit capable of receiving signals of more than one communications standard such as a GSM/UMTS phone may also be used. Other local area technologies such as IEEE 802.11 and 802.15 devices are also suitable. The skilled person will be aware of many more suitable systems, which may also be used.

CLAIMS

1. A positioning method for a mobile unit (2) used in a network having a plurality of fixed base stations (20) linked to a location server (26), comprising:

receiving in a mobile unit (2) signals (52) from a number of the fixed base stations (20) and creating a list (14) of the base stations;

transmitting to one of the base stations through a communications link a location query (54) including the list of base stations from which signals are received;

passing the location query (54) through the network (24) to the location server (26); and

determining the position of the mobile unit (2) from the information transmitted in the location query (54), including the list (14) of base stations.

2. A positioning method according to claim 1, including

sending an inquiry message (50) from the mobile unit (2);

receiving the inquiry message in one or more base stations (20) and transmitting inquiry responses (52) back from those base stations to the mobile unit, the inquiry responses (52) including the address of the responding base station (20); and

listing the received addresses in the mobile station (2) for onwards transmission in the location query (54).

3. A method according to claim 1 or 2, further including:

forming a communications link (28) between the mobile unit (2) and a single one of the base stations (21);

monitoring in the mobile unit signals from others of the base stations (20); and

maintaining a handover list (14) in the mobile unit listing the addresses of the others of the base stations (20) from which signals are received;

including the handover list of base stations in the location query as the list of base stations from which signals are received; and

under predetermined conditions, handing over the communications link between the mobile unit (2) and the single one (21) of the base stations (20) to another of the base stations (20) in the handover list (14) to form a communications link (28) between the mobile unit and the other one of the base stations.

4. A positioning method according to any preceding claim further comprising:

measuring the signal strength of the signals received in the mobile unit from the fixed base stations (20); and

including the signal strength information in the location query (54) passed to one of the base stations (21);

wherein the step of determining the position uses the signal strength information and the list of base stations to determine the position of the mobile unit.

5. A positioning method according to any preceding claim wherein the base stations (20) are Bluetooth access points and the mobile unit (2) is a Bluetooth device.

6. A positioning method according to any of claims 1 to 4 wherein the base stations (20) are cellular telephony base stations and the mobile unit (2) is a cellular mobile unit.

7. A mobile unit for use with a network of base stations having a location server; the mobile unit comprising:

a transceiver (2) for transmitting messages to and receiving messages from the base stations; and

a processor (8) arranged to receive signals from a number of the base stations; and to transmit to one of the base stations a location query including

a list of the base stations from which signals are received, so that the receiving base station can pass the location query through the network to the location server to determine the position of the mobile unit from the information transmitted in the location query, including the list of base stations.

8. A mobile unit according to claim 7 wherein the mobile unit is arranged:

to send an inquiry message (50) from the mobile unit;

to receive inquiry responses (52) back from one or more of the base stations (20), the inquiry responses (52) including the address of the responding base station;

to list the received addresses in the mobile unit (2), and

to include the list of received addresses in the location query (54).

9. A mobile unit (2) according to claim 7 or 8 wherein the transceiver (6) is a Bluetooth transceiver.

10. A system comprising:

a plurality of base stations (20) arranged in a network (24), each having a transceiver for connecting to a mobile unit; and

a location server (26) connected to the network (24) including a list of base stations (20) and their locations;

wherein the network (24) is arranged to receive in one of the base stations (20) a location query including a list of base stations in range of the mobile unit from the mobile unit and to pass the location query to the location server; and

the location server (26) is arranged to receive the location query and to determine the location of the mobile unit sending the location query using the list of base stations in range of the mobile unit and the list of base stations and their locations.

11: A system according to claim 10 further comprising: a mobile unit (2) having a transceiver (8) for transmitting messages to and receiving messages from the base stations (20); wherein the mobile unit (2) is arranged to receive signals from a number of the base stations (20); and to transmit to one of the base stations (21) a location query (54) including a list of the base stations from which signals are received.

12. A location query message (54) for sending from a mobile unit through a communications link including a list of base stations (64) from which signals are received in the mobile unit and the signal strength (66) of the signal received from each of the base stations.

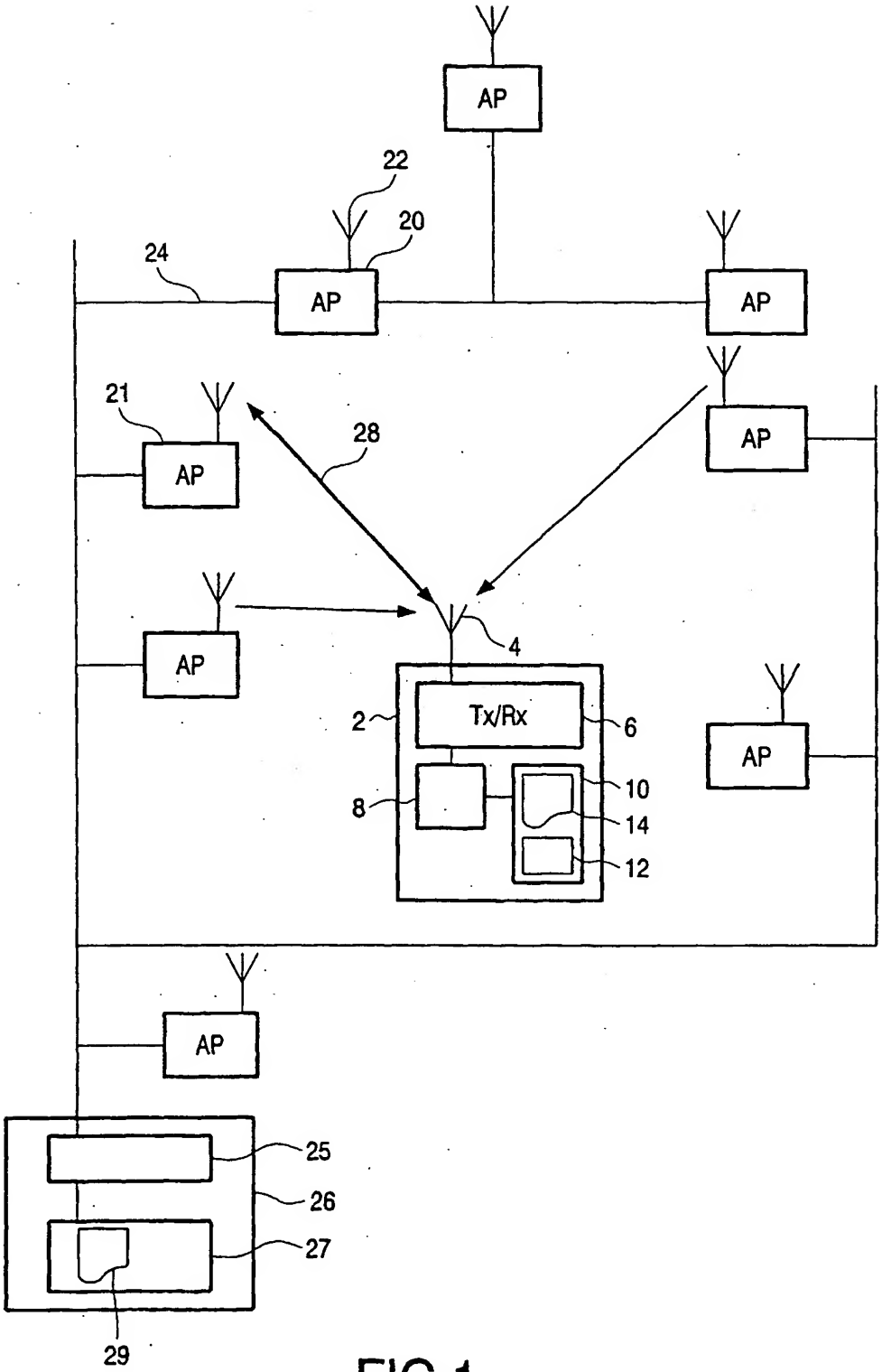

FIG.1

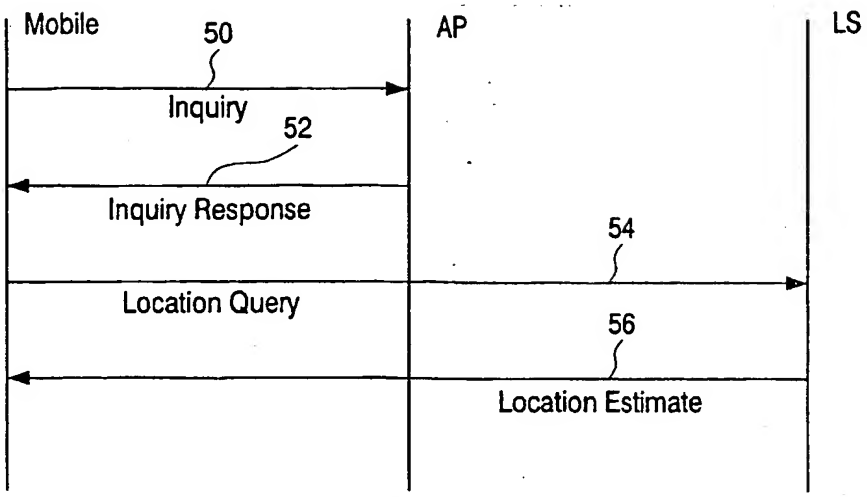

FIG.2

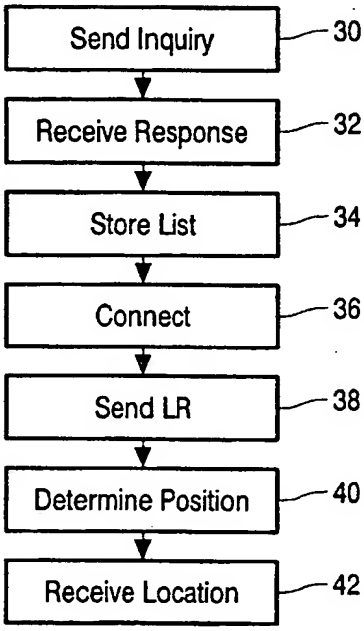

FIG.3

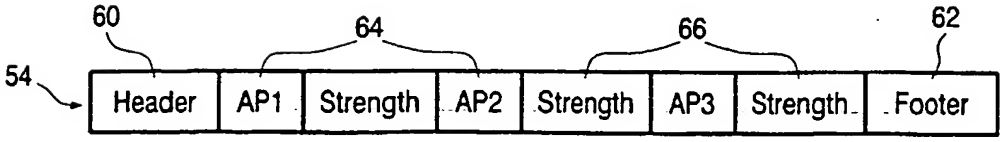

FIG.4

INTERNATIONAL SEARCH REPORT

Internation plication No
PCT/IB 03/05175

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/28 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, INSPEC, COMPENDEX, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6 134 448 A (KOSHIMA HIROAKI ET AL) 17 October 2000 (2000-10-17) abstract column 2, line 61 -column 3, line 32 column 4, line 3 - line 52 column 5, line 57 -column 7, line 49 figures 1,2,4,5 --- -/--	1,4,7, 10-12 2,3,5,6, 8,9

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 February 2004	23/02/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rosenauer, H

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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